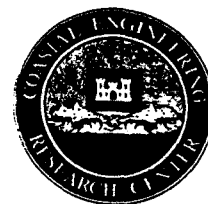# Coastal Engineering Technical Note

CHECKING STABILITY OF BULKHEADS LOCATED IN PORTS, HARBORS AND COASTAL WATERWAYS AGAINST SHEAR FAILURE
COMPUTER PROGRAM: UTEXAS2

PURPOSE: This Technical Note describes use of computer program, UTEXAS2. This slope stability program can model bulkheads and provides capability for checking stability of bulkheads against shear failure in soil below the wall.

BACKGROUND: It should be noted that in a wave enviionment there are several failure modes other than the one discussed in this Technical Note. The complete engineering of a coastal bulkhead also needs to investigate these other failure modes. In one major type of bulkhead failure the cohesive substratum upon which a bulkhead is founded can experience a slope stability failure due to weight of soil behind sheet pile wall. To investigate possibility of this type of failure of an anchored bulkhead, engineers may use a slope stability program such as UTEXAS2. Since experience has shown that failure of a bulkhead in uniform clay takes place by slippage along a surface of nearly circular cross-section, stability of bulkheads against a general deep-seated rotational failure involving sheeting and even anchorage may be checked using a limit equilibrium procedure. Although checking stability against shear failure is only one of many factors to be considered in design, the slope stability analysis is unfortunately not often made. It may be noted
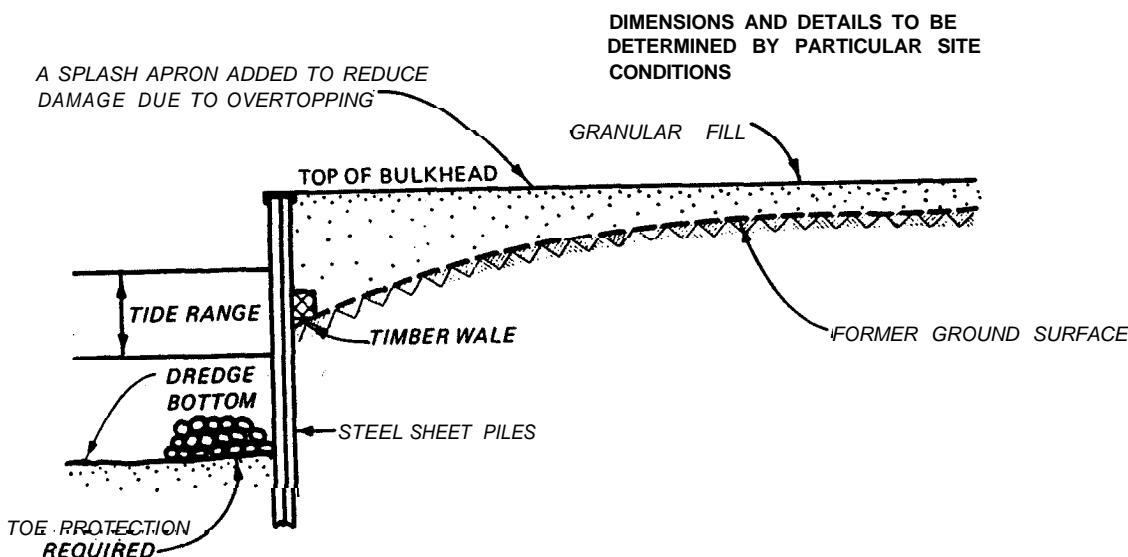

Figure 1. Steel Sheet Pile Bulkhead

that the bulkhead depicted in Figure 1 is commonly constructed dredged bulkhead for which sheet piles are driven into soil, whereafter the anchorage is installed and the soil mass in front of wall is removed by dredging. The dredge bottom refers to mudline after dredging.

UTEXAS2 calculates limit equilibrium of slopes by one of four procedures. The Spencer procedure, a rigorous procedure that evaluates both moment and force equilibrium, is the recommended procedure to estimate stability of bulkheads.

UTEXAS2 allows an engineer to model driving forces (weight of soil, piezometric conditions, and surcharge load) and resisting forces (soil shear strength, weight of water in front of bulkhead and lateral pressure exerted by water on bulkhead). The geometric configuration of bulkhead system, including soil layers, sheet piles, and water, is input by means of coordinate system. The sheet piles are modeled by using specific weight of piles as input and by using a high shear strength for the piles to prevent the critical circle from going through the piles. For circular searches, 'the engineer provides center coordinates for the initial circle and grid spacing. It is recommended that a grid spacing of 1% of the slope height be used. (The slope height is the vertical distance from dredge bottom to top of bulkhead.) Generally an engineer specifies backfill of granular material to be placed immediately behind bulkhead to preclude development of extremely large lateral pressures due to high groundwater level inside the wall after the free water on the front side has lowered and specifies a bituminous or portland cement concrete splash apron to be placed over the backfill to prevent damage due to over-topping. Such design features for a steel sheet-pile bulkhead are shown in Figure 1. Any profile configuration can be specified in UTEXAS2. The splash apron should be modeled as a surcharge load.

PROGRAM INPUT:
   1. Profile line describing geometry of granular fill, underlying clay, sheet pile wall, and water body by means of x,y coordinates.
   2. The material properties required include unit weight, cohesion and friction angle for each type of material. Unit weight is the total weight of the soil including the soil moisture per unit volume. Cohesion of a soil is all of the shear strength not due to friction. The friction angle is a property of the soil used to compute its shearing strength as a result of friction between the particles. Surface pressure exerted by the splash apron is the increase in pressure transmitted to the underlying fill due to the weight of the concrete or asphalt pavement of which the splash apron is constructed. (There are several different ways to specify the cohesion and friction angles.)
   3. Piezometric line by means of x,y coordinates
   4. Surface pressure exerted by splash apron
   5. Initial estimate of x,y coordinates at center of critical circle
   6. Initial estimate of critical circle radius
   7. Required accuracy (such as to nearest 0.5 ft)
   8. Minimum elevation below which critical shear surface not allowed to pass.
   9. Procedure to be used; Spencer method is recommended.
Note that input data is free format controlled by command words and that the program is batch oriented requiring the data file be generated beforehand.

PROGRAM OUTPUT: UTEXAS2 generates table of input data providing a record of the information used in the analysis, tables of search results listing the circle center and the calculated safety factor for each circle evaluated, and tables of details of the critical surface including the final safety factor. It is recommended that hand checks of the critical circle be performed for all final designs.

PROGRAM AVAILABILITY: The program is available for the IBM PC and may be obtained from Ms. Gloria J. Naylor at (601) 634-2581), FTS: 542-2581, Engineering Computer Programs Library Section, Technical Information Center, U.S. Army Engineer Waterways Experiment Station, P.O. Box 631, Vicksburg, Mississippi 39180-0631. Also it is available in the Corps library on both CDC and Harris computers. Questions concerning application of UTEXAS2 can be directed to geotechnical engineers, in the field offices, or to Mr. Earl Edris at (601) 634-3378 (FTS 542-3378) or Mr. Gordon E. Staab at (601) 634-2139 (FTS 542-2139). This program is for exclusive use of Corps of Engineers personnel as it is a proprietary program. Any others wishing to we this program should contact Mr. Stephen G. Wright, University of Texas.

SAMPLE PROBLEM: A steel sheet pile bulkhead with granular backfill, founded upon soft clay, with a splash apron of concrete with a unit weight of 150 pounds per cubic foot, and with depth of water on its seaward face of 10 feet was modeled.

SAMPLE RUN: UTEXAS2 searched numerous circles to determine minimum value of factor of safety and parameters associated with final critical circle as shown in fable 1.

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*************************************************
*                                               *
* FINAL RESULTS FOR SHEAR SURFACE (CRITICAL     *
* SURFACE IN CASE OF A SEARCH)                  *
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SPENCER'S PROCEDURE USED TO COMPUTE FACTOR OF SAFETY
Factor of Safety = 1.880   Side Force Incilnation   = *15.03 Degrees*

--------------------VALUES AT RIGHT SIDE OF SLICE-----------------

Slice NO.	X-Right	Side Force	Y-Coord. of Side Force Location	Fraction Of Height	Sigma at TOP	Sigma at Bottom
1	3.9	-6759.	24.5	.538	-7293.5	-4711.9
2	4.2	-8103.	24.7	.867	-8749.2	3287.3
3	4.6	-5493.	25.1	ABOVE	-6901.8	3596.1
4	5.1	-4867.	25.7	ABOVE	−5559.6	3341.5
5	5.6	-4216.	26.7	ABOVE	-4623.7	3070.2
6·	5.2	-3540.	28.3	ABOVE	-3946.1	2848.3
7	8.8	-2843	30.9	ABOVE	-3435.7	2668.9
8	7.4	-2131.	35.7	ABOVE	-3038.1	2528.4
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
51	44.3	153.	13.7	BELOW	-210.2	255.9
52	44.7	-120.	32.7	ABOVE	-194.5	152.1
53	45.0	-287.	27.2	.808	-180.0	53.1
54	45.3	-347.	28.7	.608	-188.0	-36.1
55	45.4	-345.	26.7	.580	-104.5	-57.9
56	45.6	-282.	27.1	.515	-155.9	-130.7
57	46.8	-140.	27.6	.462	-132.5	-210.8
58	45.9	Ø.	35.8	ABOVE	.Ø	.a

Table 1

REFERENCES:

Edris, E.V., Jr. and Vanadit-Ellis, W. 1982. "Geotechnical Computer Program Surveys," Miscellaneous Paper No. GL-82-1, U.S. Amy Engineer Waterways Experiment Station, Vicksburg, MS

Spencer, E. 1967. "A Method of Analysis of the Stability of Embankments Assuming Parallel Inter-Slice Forces," Geotechnique, Vol 17, No. 1, pp 11-26.